Avoidance of bee and wasp stings: an entomological perspective

Albert Greene[a] and Nancy L. Breisch[b]

Purpose of review

Clinicians and researchers in allergy and immunology are often unaware of aspects of stinging insect biology that would be of practical interest to their patients. This review discusses entomological literature pertaining to avoidance of bee and wasp stings, with emphasis on risk factors associated with provoking individual foragers versus disturbing colonies and preventive measures for both circumstances.

Recent findings

Recent work pertaining to sting avoidance has mostly been concerned with the development and testing of attractants, insecticides and delivery systems for toxic baiting programs to control vespine wasps.

Summary

Sting risks and avoidance measures associated with bee and wasp foragers are different from those posed by disturbing colonies. Despite widespread advice to the contrary, no evidence currently exists that wearing perfume or bright, floral-colored clothing elevates sting risk. Foragers usually have to be firmly touched before they will sting; therefore, personal protection largely involves guarding against accidental direct contact. Although still under development, the most effective means for reducing local populations of foraging vespine wasps are toxic baiting programs. Preventing stings from colonies is more problematic and depends mostly on personal awareness when disturbing vegetation. The most effective measure in mitigating the severity of a mass attack is probably the wearing of white or light-colored clothing.

Keywords

bees, colony control, social insect defense, sting avoidance, toxic baiting, wasps

Curr Opin Allergy Clin Immunol 5:337–341.

[a]Service Delivery Support Division, US General Services Administration, Washington, District of Columbia, USA and [b]Department of Entomology, University of Maryland, College Park, Maryland, USA

Correspondence to Albert Greene, PhD, Service Delivery Support Division (WPY), US General Services Administration, 7th and D Sts SW, Washington, DC 20407, USA
Tel: +1 202 205 5703; fax: +1 202 401 3722; e-mail: albert.greene@gsa.gov

Current Opinion in Allergy and Clinical Immunology 2005, 5:337–341

1528-4050

Introduction

Although instruction on prophylactic measures is clearly appropriate for patients suffering from Hymenoptera sting anaphylaxis, surveys suggest this critical information is not being routinely delivered, particularly in acute care settings [1–3]. Much of the primary entomological literature pertaining to realistic avoidance of bee and wasp stings, however, is not consulted by allergists and clinical immunologists, and several misconceptions have become widespread throughout the medical community.

Stings from individual workers

Bee and wasp stings occur under two distinct sets of circumstances. The first involves encounters with individual workers away from their nest that are foraging for food, water or building materials.

Wardrobe and cosmetics

Public information literature distributed by the allergy/immunology community often contains advice concerning wardrobe and cosmetic selection to minimize the chances of being stung. A representative example of this guidance states 'Many stinging insects are foraging for food, so don't look or smell like a flower – avoid brightly colored clothing and perfume when outdoors' [4].

In fact, no empirical evidence exists that perfume or bright, floral-colored clothing significantly increases a person's attractiveness to foraging Hymenoptera, much less the risk of getting stung by them. Orientation to flowers by honey bees is governed by a complex suite of integrated factors that include floral colors, patterns and shapes, specific floral odors supplemented by multiple olfactory cues provided by the local environment, and the recent foraging history of individual workers [5–7]. Unlike humans, bees are most sensitive to the short-wavelength end of the spectrum, particularly ultraviolet light, followed by blue–violet and green. They are least sensitive to orange and cannot perceive red [5,6]. As a result, flowers that depend on bees for pollination typically have evolved distinctive ultraviolet patterns that are highly visible to the insects but are often not perceived by humans [5,8]. The bottom line for the public is that the search image of foraging bees is unlikely to be triggered by a large patch of colored cloth that appears bright to humans but has limited or no biological significance to Hymenoptera.

In contrast to apparel, it would seem more likely that some cosmetic fragrances might attract the attention of

nearby foragers, because in addition to floral nectar, both honey bees and certain vespines collect carbohydrates from a wide array of natural and anthropogenic sources, particularly fermenting fruit and sweet beverages and foods [9,10]. Orientation to these resources clearly involves olfactory recognition of volatile cues [9,11,12]. Nevertheless, we are unable to find any quantitative data demonstrating a significant attraction of any cosmetic product for any Hymenoptera species. A different type of potential association has been reported with the hornet, *Vespa mandarinia*, which has an alarm pheromone that includes alcohols and esters used in food flavorings and cosmetic fragrances [13]. It is unknown, however, whether or not any specific product incorporating these chemicals elicits defensive behavior by this species.

Risk factors and sting prevention

Due to the ease with which some bee or wasp colonies can be stimulated to attack in defense of their nest, the public often mistakenly thinks of these insects as inherently aggressive under any circumstances. In reality, the 'rules of engagement' for social Hymenoptera are rigidly constrained, and stings by individual foragers away from the nest are almost always provoked by firm, accidental contact such as stepping on one, taking it into the mouth with food or drink, or pressing/striking it with the hand. Risk of getting stung is therefore highly elevated in locations where large numbers of bees or wasps have congregated to feed, particularly where humans are doing the same [14–17].

Preventive measures in these circumstances, such as at picnic areas and concession stands, can be grouped into two categories. The first pertains to modifying personal behavior to minimize accidental contact with foragers, with emphasis on maintaining a high level of vigilance as to the presence of bees and wasps in the immediate vicinity, not walking with exposed feet and exercising extreme care with beverages [14,18]. Drinking directly out of cans or bottles presents the greatest risk, as these containers are readily entered by inquisitive foragers which are subsequently concealed from view. Tightly lidded cups with inserted straws are often recommended as safer than open cups, but do not totally exclude entry by the smaller species. Despite advertising claims to the contrary, there are currently no effective repellent products for foraging bees or wasps, although observations that orange peels [12], a Meliaceae extract [19] and a bitter chemical from watermelons [20] repel foraging *Vespula* suggest promising avenues for research. Depending upon the extent of a patient's concern, the most appropriate advice might be simply to not eat or drink outdoors during the warm months.

The other approach to preventing stings associated with foraging bees and wasps involves implementing measures to reduce the number of foragers. One method is to minimize local sources of attraction, such as tightly covering food and waste receptacles, frequent cleaning of food residues, frequent removal of refuse, fallen fruit and dog or other animal feces (as the attendant flies are hunted by some wasp species), and elimination of landscape plantings that attract large numbers of carbohydrate-seeking Hymenoptera [14,17,18].

Another tactic is to attempt to reduce forager populations with the use of baits, either by luring the insects into traps or as a means to deliver a pesticide. Numerous models of wasp traps are on the market [21,22], but unless very large numbers are deployed and continually serviced, they tend to be swamped by the constantly replenishing colonies within foraging range and are therefore of dubious value in most circumstances [21,23,24]. Toxic baiting programs hold the greatest promise for success but their methodology is still under development to solve the challenges of affordability, insecticide efficacy, exclusion of non-target species and sustainability of bait attractiveness [11,25–27]. The quest to discover durable, highly effective artificial attractants with efficient dispensing systems is currently one of the most active fields of applied vespine research [11,28–33].

Stings from colonies

In contrast to the pressure of direct contact needed to provoke stinging from most individual foragers, group defensive behavior by a social wasp or bee colony may be elicited by considerably more subtle stimuli – typically some abrupt movement of the nest (often due to vibration of its immediate surroundings) but, in some cases, just nearby motion, the approach of a dark object or mammalian breath [17,34–36]. Consequences for the human or animal source of the disturbance are usually far more severe than those from an encounter with an individual forager. Mature colonies of some species are potentially capable of delivering hundreds or even thousands of stings almost instantaneously [35].

Arousal thresholds and intensity of aggressive response varies widely among social Hymenoptera and are dependent on species (or subspecies and even finer degrees of genetic lineage in the case of honey bees) and a colony's age, size and past history of disturbance [17,34,36,37•]. The major problem universally posed by these insects is the cryptic nature of their nests, many of which are concealed in cavities above or below ground. Even large nests in vegetation or attached to structures are typically obscured by foliage, overhangs or shadow and can escape detection even at close range [36].

Common sources of stings

Three common sources of bee and wasp stings prevail in the United States. Polistine wasps, commonly called

paper wasps, have small colonies of usually no more than a few dozen workers, but their nests can be extremely abundant around human habitations. The most pestiferous species is the recently arrived *Polistes dominulus* – an invasive Old World wasp that nests in both exposed and protected locations, including readily disturbed structural cavities such as hollow fencing, light fixtures and playground equipment [38–42].

Vespine wasps, commonly called yellowjackets or hornets, are generally considered to be the most common source of stings, due to their abundance, aggressiveness and relatively large colony size (up to several thousand workers) of some species [17,43]. Colonies typically have a single queen and last for one season only. In areas with mild winters, including Florida, California and Hawaii, however, multiple queens may inhabit the same nest and produce enormous perennial colonies with a high potential for mass stinging [44–46].

Although honey bees are often invoked as a sting hazard, accidental disturbance of feral colonies in the United States was rare until relatively recently, because nests were typically located within tree cavities or structural voids [47,48]. The arrival of Africanized bees (*Apis mellifera scutellata*) in 1990 markedly increased the stinging risk for people and domestic animals in several southwestern states, as this subspecies has an extremely low defensive response threshold, is capable of some of the most severe attacks known for any social insect, and establishes nests in a wide variety of locations that are subject to human disturbance [37•,49–51].

Risk factors and sting prevention

Preventive measures if a social wasp or bee nest has been detected in an undesirable location normally involves killing the workers. Although insecticide products labeled for stinging insects are readily available to the general public, we strongly feel this activity should never be attempted by anyone who has not received specialized training and is not equipped with protective clothing [14,15]. Precise methodology of nest control operations is highly variable, depending on species and circumstances. The process often requires extensive experience to protect the safety of bystanders, and, in some cases, a vacuum is recommended to reduce the number of workers prior to applying insecticide. Despite wide interest in chemical-free methods of pest control, total replacement of pesticides with vacuums is not feasible in many situations. In general, rapid-knockdown aerosols are the most efficient formulations for exposed nests, while dusts are considered best for nests in cavities. It is not unusual for the initial treatment of a large colony to be only partially successful [52,53].

As it is the undiscovered colony that is the most hazardous, and as a concealed bee or wasp nest may be encountered virtually anywhere, the single greatest risk factor for multiple stinging by a disturbed colony is simply being outdoors in a spot where other humans do not frequently go. This typically implies somewhere with vegetation, so the more time spent in natural areas – particularly off well-established paths – the higher the risk. For people who live and work in developed locations, activities in parks, yards or gardens are most likely to bring them into accidental contact with a nest. Those activities producing vibration and disturbance to vegetation, such as walking or playing with a dog or mowing, pruning and string-trimming are most likely to result in stinging [17,35]. In particular, gasoline-powered lawn mowers have the distinction of being perhaps the most efficient means for stimulating wasp or bee colonies to attack. Producing noise, vibration, odors and heat, these machines have been termed 'the perfect predator' from the insects' point of view [35].

Personal rescue actions

Outdoor activities are either difficult to avoid or highly pleasurable for many people; therefore, the most useful advice often involves a few common-sense guidelines for personal behavior once a nest is disturbed [35,54]:

(1) If only a few bees or wasps are flying around you, slowly walk away from the area without flailing the arms. Sudden motion often exacerbates attack behavior and increases the chance of accidental contact.
(2) If many insects suddenly start to fly around you, or if you are being stung, run from the area without delay and cover your mouth and nose while running. Stinging insects tend to target the facial area, which can quickly produce panic and disorientation in the victim.
(3) If possible, seek shelter in a building or enclosed vehicle.

Mitigating the severity of attacks

Few readily deployed measures that might mitigate the intensity of colony defense behavior are available. Attacking bees and wasps are strongly attracted to dark colors (one reason why eyes, mouth and nostrils are selectively targeted), so white or very light-colored clothing that covers most of the body should confer some advantage [54,55]. Although it has been suggested that an aerosol spray of the common insect repellent N,N-diethyl-*m*-toluamide (DEET) is effective at decreasing the magnitude of mass honey bee attacks [56], other research has not shown any meaningful effect [57]. In fact, one repellent product (Repel X, Farnam Companies, Phoenix, AZ) actually stimulated a more severe attack response [57]. On the other hand, an intriguing report of

human sweat-mediated protection against colony defense by a tropical wasp species [58] merits further investigation. Smoke has been shown to reduce defensive behavior in both honey bees and yellowjackets [55], although this would seem to have limited practical value in an unexpected confrontation. Persons with outdoor occupations that present an elevated risk for disturbing colonies have the option of carrying at least minimal protective equipment with them (e.g. a compact mesh veil to cover the head), and firefighters in natural areas are urged to take refuge in a personal fire shelter (a standard protective item made from aluminum foil, fiberglass and woven silica) in the case of severe stinging insect attack [54].

Conclusion

Despite progress in refining toxic baiting programs for area-wide abatement of foraging wasps, it is likely that these and other stinging insects will remain a common part of the outdoor experience for most people. In view of the current lack of effective methods to repel bees or wasps that are either attracted to food or defending their nest, personal awareness and avoidance of situations presenting a high sting risk remain the most important preventive measures.

Acknowledgement

The authors are grateful to Dr David B.K. Golden for valuable comments on the manuscript.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

1 McDougle L, Klein GL, Hoehler FK. Management of Hymenoptera sting anaphylaxis: a preventive medicine survey. J Emerg Med 1995; 13:9–13.

2 Moffitt JE, Yates AB, Stafford CT. Allergy to insect stings: a need for improved preventive management. Postgrad Med 1993; 93:197–199, 203–204, 207–208.

3 Hutcheson PS, Slavin RG. Lack of preventive measures given to patients with stinging insect anaphylaxis in hospital emergency rooms. Ann Allergy 1990; 64:306–307.

4 Public Education Committee. Stinging insect allergy. Amer Acad Allergy Asthma Immunol. Tips to Remember 2003. http://www.aaaai.org/patients/publicedmat/tips/stinginginsect.stm.

5 Gould JL, Gould CG. The honey bee. New York: Scientific Amer Library; 1988.

6 Winston M. The biology of the honey bee. Cambridge, MA: Harvard Univ Press; 1987.

7 Michener CD. The social behavior of the bees. Cambridge, MA: Belknap Press of Harvard Univ Press; 1974.

8 Free JB. The effect of flower shape and nectar guides on the behaviour of foraging honeybees. Behaviour 1970; 37:269–285.

9 Raveret Richter M. Social wasp (Hymenoptera: Vespidae) foraging behavior. Ann Rev Entomol 2000; 45:121–150.

10 Edwards R. Social wasps: their biology and control. East Grinstead, UK: Rentokil; 1980.

11 Day SE, Jeanne RL. Food volatiles as attractants for yellowjackets (Hymenoptera: Vespidae). Environ Entomol 2001; 30:157–165.

12 Jander R. Olfactory learning of fruit odors in the eastern yellow jacket, *Vespula maculifrons* (Hymenoptera: Vespidae). J Insect Behav 1998; 11:879–888.

13 Ono M, Terabe H, Hori H, Sasaki M. Components of giant hornet alarm pheromone. Nature 2003; 424:637–638.

14 Mallis A. Handbook of pest control. 9th ed. Cleveland, OH: GIE Media; 2004.

15 Bennett GW, Owens JM, Corrigan RM. Truman's scientific guide to pest management operations. 6th ed. Cleveland, OH: Advanstar; 2003.

16 Vetter RS, Visscher PK. Bites and stings of medically important venomous arthropods. Int J Dermatol 1998; 37:481–496.

17 Akre RD, MacDonald JF. Biology, economic importance and control of yellow jackets. In: Vinson SB, editor. Economic impact and control of social insects. New York, NY: Praeger; 1986. pp. 353–412.

18 Pinto L. Using IPM against yellowjackets and honey bees. Pest Control 1998; 66(7):12, 14–15.

19 Braverman Y, Chizov-Ginzburg A, Yeruham I, *et al.* Control experiments with yellow jacket wasps (Hymenoptera: Vespidae) injuring cattle in Israel. J Econ Entomol 1998; 91:486–491.

20 Chambliss OL, Jones CM. Cucurbitacins: specific insect attractants in Cucurbitaceae. Science 1966; 153:1392–1393.

21 Gulmahamad H. Yellowjacket control gets creative. Pest Control 2002; 70(7):34, 36, 38, 40–41.

22 Christie GD. Evaluation of non-toxic bait traps for yellowjacket control. Pest Control 1994; 62(8):38–39.

23 Toft RJ, Harris RJ. Can trapping control Asian paper wasp (*Polistes chinensis antennalis*) populations? N Z J Ecol 2004; 28:279–282.

24 Cooper P. Taking the bite out of bee sting occurrences. Pest Control 1998; 66(6):40–42.

25 Harris RJ, Etheridge ND. Comparison of baits containing fipronil and sulfluramid for the control of *Vespula* wasps. N Z J Zool 2001; 28:39–48.

26 Sackmann P, Rabinovich M, Corley JC. Successful removal of German yellowjackets (Hymenoptera: Vespidae) by toxic baiting. J Econ Entomol 2001; 94:811–816.

27 Beggs JR, Toft RJ, Malham JP, *et al.* The difficulty of reducing introduced wasp (*Vespula vulgaris*) populations for conservation gains. N Z J Ecol 1998; 22:55–63.

28 Aldrich JR, Zhang Q-H, Zhang A. Synergistic chemical attraction of the eastern yellowjacket, *Vespula maculifrons*. J Entomol Sci 2004; 39:643–653.

29 Landolt PJ, Reed HC, Ellis DJ. Trapping yellowjackets (Hymenoptera: Vespidae) with heptyl butyrate emitted from controlled-release dispensers. Florida Entomol 2003; 86:323–328.

30 Reed HC, Landolt PJ. Trap response of Michigan social wasps (Hymenoptera: Vespidae) to the feeding attractants acetic acid, isobutanol, and heptyl butyrate. Great Lakes Entomol 2002; 35:71–77.

31 D'Adamo P, Corley JC, Lozada M. Attraction of *Vespula germanica* (Hymenoptera: Vespidae) foragers by conspecific heads. J Econ Entomol 2001; 94:850–852.

32 Landolt PJ, Smithhisler CS, Reed HC, McDonough LM. Trapping social wasps (Hymenoptera: Vespidae) with acetic acid and saturated short chain alcohols. J Econ Entomol 2000; 93:1613–1618.

33 Landolt PJ. Chemical attractants for trapping yellowjackets *Vespula germanica* and *Vespula pensylvanica* (Hymenoptera: Vespidae). Environ Entomol 1998; 27:1229–1234.

34 Schmidt JO. Mass action in honey bees: alarm, swarming and the role of releaser pheromones. In: Vander Meer RK, Breed MD, Espelie KE, Winston ML, editors. Pheromone communication in social insects. Boulder, CO: Westview Press; 1998. pp. 257–290.

35 Schmidt JO, Boyer Hassen LV. When Africanized bees attack: what you and your clients should know. Vet Med 1996; 91:923–928.

36 Akre RD, Reed HC. Vespine defense. In: Hermann HR, editor. Defensive mechanisms in social insects. New York, NY: Praeger; 1984. pp. 59–94.

37 • Breed MD, Guzmán-Novoa E, Hunt GJ. Defensive behavior of honey bees: organization, genetics, and comparisons with other bees. Ann Rev Entomol 2004; 49:271–298.
A comprehensive review of the components of honey bee defensive behavior, with comparisons with other bee species.

38 Johnson RN, Starks PT. A surprising level of genetic diversity in an invasive wasp: *Polistes dominulus* in the northeastern United States. Ann Entomol Soc Amer 2004; 97:732–737.

39 White G. Hunting *Polistes dominulus*. Pest Control Tech 2004; 32(9):58, 60–62, 64.

40 Cervo R, Zacchi F, Turillazi S. *Polistes dominulus* (Hymenoptera, Vespidae) invading North America: some hypotheses for its rapid spread. Insectes Soc 2000; 47:155–157.

41 Gamboa GJ, Noble MA, Thom MC, *et al.* The comparative biology of two sympatric paper wasps in Michigan, the native *Polistes fuscatus* and the invasive *Polistes dominulus* (Hymenoptera, Vespidae). Insectes Soc 2004; 51:153–157.

42 Gamboa GJ, Greig EI, Thom MC. The comparative biology of two sympatric paper wasps, the native *Polistes fuscatus* and the invasive *Polistes dominulus* (Hymenoptera, Vespidae). Insectes Soc 2002; 49:45–49.

43 Akre RD, Greene A, MacDonald JF, *et al.* The yellowjackets of America north of Mexico. USDA Agric Handbook 1981; 552:1–102.

44 Visscher PK, Vetter RS. Annual and multi-year nests of the western yellowjacket, *Vespula pensylvanica*, in California. Insectes Soc 2003; 50:160–166.

45 Pickett KM, Osborne DM, Wahl D, Wenzel JW. An enormous nest of *Vespula squamosa* from Florida, the largest social wasp nest reported from North America, with notes on colony cycle and reproduction. J N Y Entomol Soc 2001; 109:408–415.

46 Greene A. *Dolichovespula* and *Vespula.* In: Ross KG, Matthews RW, editors. The social biology of wasps. Ithaca, NY: Cornell Univ Press; 1991. pp. 263–305.

47 Seeley TD, Morse RA. Nest site selection by the honey bee, *Apis mellifera*. Insectes Soc 1978; 25:323–337.

48 Seeley TD, Morse RA. The nest of the honey bee (*Apis mellifera* L.). Insectes Soc 1976; 23:495–512.

49 Visscher PK, Vetter RS, Baptista FC. Africanized bees, 1990–1995: initial rapid invasion has slowed in the US. Calif Agric 1997; 51:22–25.

50 Sherman RA. What physicians should know about Africanized honeybees. Western J Med 1995; 163:541–546.

51 Winston ML. The biology and management of Africanized honey bees. Ann Rev Entomol 1992; 37:173–193.

52 Greene A. Sucking up stingers. Pest Control Tech 2004; 32(8):70–74.

53 Greene A. Born to gnaw. Pest Control Tech 2003; 31(8):49–50, 53–54, 56.

54 Vetter RS, Parker BT, Visscher PK. Can fire shelters protect firefighters from bee and yellowjacket stings? Fire Mgmt Notes 1998; 58: 21–26.

55 Visscher PK, Vetter RS. Smoke and target color effects on defensive behavior in yellowjacket wasps and bumble bees (Hymenoptera: Vespidae, Apidae) with a description of an electronic attack monitor. J Econ Entomol 1995; 88:579–583.

56 Collins AM, Rubink WL, Cuadriello Aguilar JI, Hellmich RL II. Use of insect repellents for dispersing defending honey bees (Hymenoptera: Apidae). J Econ Entomol 1996; 89:608–613.

57 Schmidt JO, Johnston AN, Ginter DL, Spangler HG. Olfactory stimulation of africanized honey bee (Hymenoptera: Apidae) attacks by insect repellents. J Med Entomol 2003; 40:275–278.

58 Young AM. A human sweat-mediated defense against multiple attacks by the wasp *Polybia diguetana* in northeastern Costa Rica. Biotropica 1978; 10:73–74.